Journal MVZ Córdoba
2022; may-august. 27(2):e2444
https://doi.org/10.21897/rmvz.2444

Original

Characterization and technological classification of the dual-purpose bovine system of the Huasteca region in Veracruz state, Mexico

Armando Arrieta-González[2,3] ✉; Antonio Hernández-Beltrán[1,2] ✉; Manuel Barrientos-Morales[1,2] ✉; David I. Martínez-Herrera[2] ✉; Patricia Cervantes-Acosta[1,2] ✉; Araceli Rodríguez-Andrade[4] ✉; Belisario Dominguez-Mancera[1,2*] ✉

[1]Universidad Veracruzana, Facultad de Medicina Veterinaria y Zootecnia, Grupo Ganadería y Cambio Climático. Miguel Ángel de Quevedo s/n esquina Yáñez Col. Unidad Veracruzana CP 91710. México.
[2]Universidad Veracruzana, Doctorado en Ciencias Agropecuarias, Facultad de Medicina Veterinaria y Zootecnia. Miguel Ángel de Quevedo s/n esquina Yáñez Col. Unidad Veracruzana CP 91710. México.
[3]Tecnológico Nacional de México, ITS Tantoyuca, Maestría en Producción Pecuaria Tropical. Desviación Lindero Tametate s/n, Col. La Morita. CP 92100. México.
[4]Tecnológico Nacional de México, IT Veracruz, Departamento de Química y Bioquímica. Calz. Miguel Angel de Quevedo 2779, Col. Formando Hogar, Veracruz. CP 91897. México
*Correspondencia: beldominguez@uv.mx

Received: July 2021; Accepted: December 2021; Published: May 2022.

ABSTRACT

Objective. To characterize the dual-purpose bovine system (SPDP, by its acronym in Spanish) by livestock production units (UPP, by its acronym in Spanish) put in place in some municipalities of the Huasteca Alta Veracruzana region (HAV), and to determine the typology of UPP within the SPDP. **Materials and methods.** Using social variables of cattle producer and quantitative variables of the farms; technological indices, grouped in zootechnics practices (Reproduction, health, nutrition, forage, and management), information from 135 UPP within the SPDP, collected through surveys and on-site visits, and records of their social, economic and livestock activities. Likewise, the climate panorama was analyzed using information from meteorological stations within the region. Multivariate K-means and Cluster analysis (Statistica V10) were used; thus, it was possible to identify five groups of UPP, classified as follows: Business (n = 4), Transition (n = 29), Traditional High (n = 34), Medium (n = 37) and Low (n = 31). Socioeconomic, productive, and farm-specific variables were analyzed with One-way ANOVA. **Results.** The Business and Transition UPP differed ($p<0.05$) from Traditional types in that they counted with a greater area (in hectares) destined to livestock farming, as well as a greater number of cows and higher technological indices of health, nutrition and economic ($p<0.05$), characteristics that yield a higher income from the sale of milk and feeder calves. **Conclusions.** The SPDP technological index goes from 0.37±0.01 to 0.61±0.06 (low-medium); which, paired with the current weather conditions, affects its productivity.

Keywords: Livestock farming; animal sciences; cattle (*Source: USDA*).

How to cite (Vancouver).
Arrieta-González A, Hernández-Beltrán A, Barrientos-Morales M, Martínez-Herrera DI, Cervantes-Acosta P, Rodríguez-Andrade A, Dominguez-Mancera B. Characterization and technological classification of the dual-purpose bovine system of the Huasteca region in Veracruz state, Mexico. Rev MVZ Cordoba. 2022; 27(2):e2444. https://doi.org/10.21897/rmvz.2444

ISSNL: 0122-0268

RESUMEN

Objetivo. Caracterizar el sistema de producción bovino doble propósito (SPDP) en unidades de producción pecuaria (UPP) de municipios de la Huasteca Alta Veracruzana (HAV) y determinar la tipología de las UPP dentro del SPDP. **Materiales y métodos.** Con variables sociales (productor), cuantitativas del hato e índices tecnológicos, agrupados en áreas zootécnicas (Reproducción, Salud, Nutrición, Pastos y Administrativa) se analizó la información de 135 UPP del SPDP recabada a través de encuestas y visitas *in situ*, con registros de sus actividades sociales, económicas y pecuarias; así mismo, se analizó el panorama climatológico con información de estaciones meteorológicas de la región. Se utilizó el análisis multivariados K-means y Conglomerado (Statistica V10); con ello, se logró identificar cinco grupos de UPP catalogándose como: Empresarial (n=4), Transición (n=29), Tradicional Alto (n=34), Medio (n=37) y Bajo (n=31). Con ANDEVA de una vía fueron analizadas las variables socioeconómicas, productivas y propias del hato. **Resultados.** Las UPP Empresarial y Transición se diferenciaron ($p<0.05$) de las de tipo Tradicional por poseer una mayor superficie (hectáreas) utilizada para la ganadería, número de vacas y mayores índices tecnológicos de salud, nutrición y económico ($p<0.05$), características que describen la obtención de mayores ingresos por venta la de leche y becerros para la engorda. **Conclusiones.** El índice tecnológico del SPDP es de 0.37 ± 0.01 a 0.61 ± 0.06 (bajo-medio), esta situación y las condiciones climatológicas actuales afectan su productividad.

Palabras clave: Productividad pecuaria; producción animal; ganado (*Fuente: USDA*).

INTRODUCTION

Cattle farming in Mexico follows several different production systems (PS), from those classified as highly industrialized, to others considered traditional (1). The dual-purpose cattle farming system (SPDP, by its acronym in Spanish) yields milk and meat through the sale of discarded calves and adult specimens. The cattle raised in the SPDP belongs to several different breeds and genetic groups, mainly resulting from the cross-breeding of *Bos indicus* and from Brown Swiss, Holstein, Simmental and Angus paternal lines (2). Feeding of the cattle is based on the grazing of native, introduced and genetically-enhanced grasses, as well as the use of nutritional supplements and of agricultural byproducts (citrus waste) in certain periods of the year. (3,4,5).

The SPDP is present all across Mexican territory, but 80% is concentrated in the states of Chiapas, Tabasco, Veracruz, and the Huasteca region, which comprises the south portion of the state of Tamaulipas, Eastern San Luis Potosí, Northern Hidalgo and Veracruz. Its' agroecological characteristics make it suitable for double-purpose cattle farming (6). In Veracruz state, this system is the most important agri-food production chain due to the value it generates (around 16 billion MXP) (7). Research on the characterization and classification of livestock farming systems has proved to be a valuable tool for the design of strategies and methods to implement projects that improve the agri-food sector (8). In countries that count with similar agroecological characteristics to those found in Veracruz, such as southern Brazil and the tropical regions of Colombia, the technological characterization of farming systems has allowed the identification of the technical aspects that require greater attention, as well as the delimitation of strategies for the development of the agricultural and farming sectors (9,10). The characterization of farming systems allows for a better understanding of their limitations, their potential, and the windows of development available with the present circumstances (11). This characterization also fosters informed decision-making in the design of improvement plans and/or projects for the production model (12). Thus, the objective of this study is to characterize and classify the dual-purpose cattle farming system used in municipalities of the Huasteca Alta Veracruzana region, in order to analyze the differences in the socioeconomical aspects, farming management areas, farm structure and technological level.

MATERIALS AND METHODS

Study population. The study was carried out in the Huasteca Alta Veracruzana (HAV) region, which is divided in 15 municipalities, and counts with a territorial extension of 12.091 km^2. It is the second largest region of Veracruz state, covering 16.8% of its total area; it is located

in its northern portion, between longitudes 97° 24'W and 98° 42'W, and latitudes 21° 5'N and 22° 55'N (7). Climate in the region is warm, subhumid, with an average annual temperature between 75 and 78°F, and annual average rainfall between 800 and 1500 mm. With the purpose of showing the current general climate panorama of the region, weather (C°), relative humidity (%) and prevailing wind speed data (m/s) were compiled along the last 5 years (2015-2020) from weather stations near the UPP's (UPP, by its acronym in Spanish). The predominant soils in the region are *Phaeozems,* highly adequate for the establishment of grazing lands, and its topography is predominantly composed of plains and low hills (13).

Sampling. A total of 135 UPP of the SPDP were surveyed in the region, to obtain their technical information, production rates, economic and environmental data. The sampling of the UPP for this study was done through non-probabilistic methods (14), including interviews with the farmers who consented to participating actively in the study, and who fulfilled the following inclusion criteria: a) current participation in the Unión Ganadera Regional del Norte de Veracruz (Regional Cattle Producer Association of Northern Veracruz); b) they must be located in municipalities within the Huasteca Alta Veracruzana region, c) they should count with production, reproductive, health and socioeconomic data from the period of analysis (January 2018 – December 2020). The information was compiled throughout 2020.

Survey design and application. The survey used in the study was drawn up from data compiled in a participatory workshop, attended by a group of stockbreeders (n=15) with experience in the field of livestock farming (> 10 years). Before its application on the field, the survey was validated by those participants in the workshop who were willing to participate in the study, and who fulfilled the inclusion criteria of the UPP; it was composed by 130 quantitative and/or qualitative variables (questions), which were grouped in eight sections (subject areas): generalities of the stockbreeder (n=4), characteristics of the UPP (n=9), structural composition of the farm (n=10), nutrition (n=15), pasture and grazing management (n=31), reproduction and genetics (n=19), health (n=11), commercialization and administration (n=31) (15). The UPP were visited to interview the stockbreeders, and to obtain the information required for the survey.

Characterization of the SPDP. A technological index (IT) was established to select variables for the characterization and grouping of the UPP of the SPDP, which was determined using the method proposed by De Freitas and Pinheiro (16), and Juárez et al (3), that considers the use of 23 technological practices (TP), classified in 5 zootechnics areas (AZ), (Nutrition management, genetics and reproductive management, sanitary management, commercial management, and grazing management). These technological indices quantify the level of application of the PT's in each subject area, assigning values of 1 and 0 (where 0 = The TP is not applied, and 1 = The TP is applied). Calculation of the technological index in each zootechnics area, and the total index, was done through the following formula

Technological index per farming subject area:

$$IT_{area} = \frac{1}{n} * \sum_{i=1}^{n} applied\ practices$$

Where: n = applied practices per subject area, i = i-th practice applied in the subject area.

Total technological index:

$$IT_{total} = \frac{1}{N} * \sum_{j=1}^{n} áreas \sum_{i=1}^{n} applied\ practices$$

Where: N= Total applied practices (N = 23), j= j-th farming subject area, i = i-th applied practice in the j-th farming subject area (n).

UPP typologies in the Huasteca Alta Veracruzana region. The classification (typology) of the UPP was done with the calculated technological indices and the quantitative variables of the survey (3, 8), through multivariate analysis techniques (K-means clustering). Graphic grouping (dendograms) of the conglomerates (classes) was done through a complete Euclidean distance matrix; the resulting data was combined through a unweighted pair group procedure, and normalized with 1-r Pearson correlation coefficient ([Correlation distance/Maximum distance]*100) (STATISTICA V10, 2013). The differences between the created UPP groups in relation to technological practice application, productive and reproductive aspects of the farms were analyzed, and the differences in technical

knowledge, use of management technologies, livestock production and reproduction among the resulting stockbreeder groups were contrasted. Additionally, distribution and frequency statistics were drawn up from the analyzed variables. A variance analysis (ANOVA) was performed to determine the weight of each type of UPP on the quantitative variables, with a completely randomized design from the general linear model. The statistical model was the following:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Where:
Y_{ij} = is the quantitative response variable of the i-th classification of the production unit, and the j-th repetition.
μ = General average
α_i = Fixed effect of the i-th classification of the production unit.
$\varepsilon_{(i)j}$ = Unsystematic error associated to each of the surveys where ij~NI(0,σ^2)

Normality was assessed with the Shapiro–Wilk test, and homoscedasticity, through Bartlett's test ($p<0.05$); the averages were compared with the Tukey method ($p<0.05$).

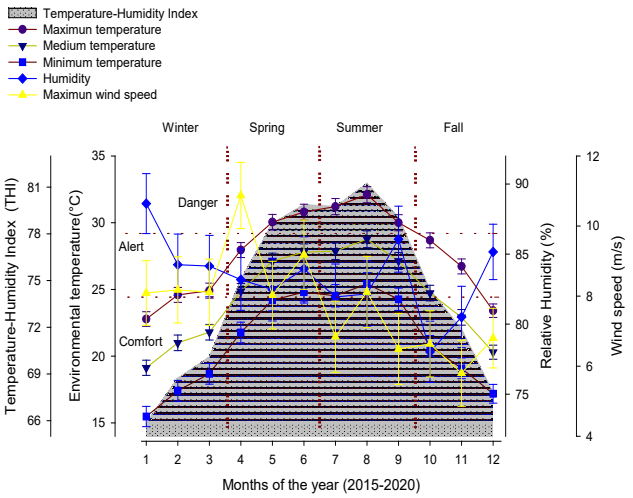

Figure 1. Basic climatological analysis of the municipalities that make up the Huasteca Alta Veracruzana region, between 2015 and 2020. The temperature-humidity index is shown, with a shaded area (▒), environmental temperature (°C) (•) Maximum, (▼) Average, (■) Minimum, (♦) Relative humidity %, (▲) maximum wind speed (m/s). Horizontal lines (---) show the comfort limit of the animals (comfort, alert, danger), and vertical dotted lines (¦) define the seasons of the year.

RESULTS

Descriptive analysis of the UPP, and climatological assessment of the municipalities of the Huasteca Alta Veracruzana region. Field work consisted in the application of 135 surveys, distributed among the municipalities involved as follows: Tantoyuca 72, Pánuco 34, Chalma 21, Tempoal 6, Platón Sánchez 1 y Ozuluama 1. All survey subjects accepted participation in this study, and fulfilled all the established inclusion criteria. Participation was highest in the municipalities of Tantoyuca and Pánuco, which concentrate 78.51% of the total sample, and count with the largest geographical extension in the region.

A descriptive analysis of the basic weather conditions of the region was carried out with the data obtained from the meteorological stations that the National Meteorological System operates in the region, located in the municipalities of Chalma (Los Hules, 30098), Cerro Azul (Presa el Moralillo, 30465), Platón Sánchez (30130), Ixcatepec (30071), Ozuluama de Mascareñas (30122), and Pánuco (El Olivo, 30051) (Figure 1).

The environmental temperature in the region rises between the months of May to August, which, in addition to the constant relative humidity (80 - 85%), means that the UPP are located in a climatological region that is unfavorable for livestock husbandry, which is evidenced by the livestock thermal safety index known as the temperature-humidity index, which surpasses 74 units, the upper limit for animal comfort.

Classification of the UPP. An initial classification of the UPP was obtained through the use of K-means and Cluster analysis, vectors of the quantitative variables (in each UPP), and the total and area-specific technological indices. Such classification was as follows: Business (n=4; 2.96%), Transition (n = 29; 21.48%) and Traditional (n = 102; 75.55%) Figure 2 y Table 1.

The dendrogram in figure 2 shows the stockbreeder groups, as well as the extent of their similarity, which can be appreciated in the vertical axis ([Correlation distance/ Maximum distance]*100), and in the horizontal axis for the UPP. Primary analysis describes three main clusters, which, for their socioeconomic and productive characteristics, have been classified as: Business, Transition and Traditional,

and significant differences (p< 0.05) can be appreciated in the studied variables (Table 1).

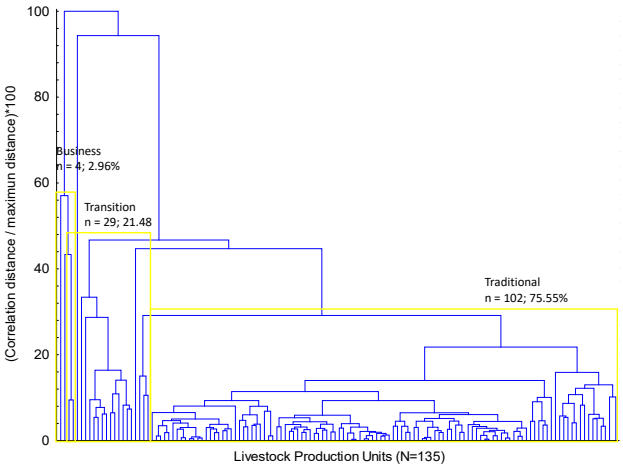

Figure 2. Dendrogram of the general classification of the UPP (N=135) of the SPDP in municipalities of the Huasteca Alta Veracruzana region, Mexico.

The UPP group labeled as Traditional represents 75.55% of the study sample (Figure 2), with different groupings within the cluster; thus, it was decided to perform a second clustering analysis, using K-means and cluster analysis, in order to determine which variables could show significant differences within this cluster. This analysis can be observed in figure 3, and the significances in table 2.

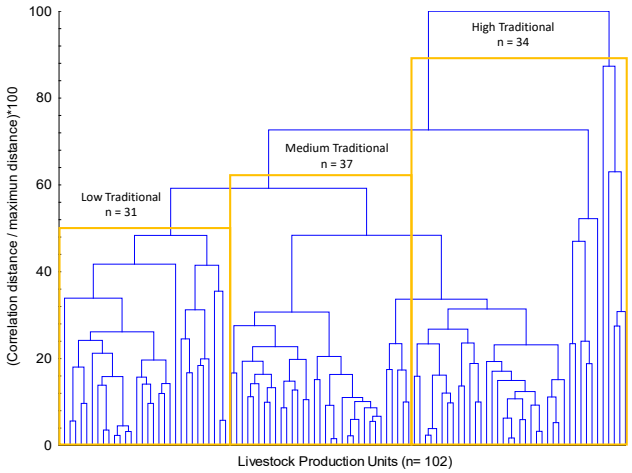

Figure 3. Dendrogram of the Traditional group of the UPP (N=102) of the SPDP in municipalities of the Huasteca Alta Veracruzana region, Mexico.

The dendrogram of figure 3 is a tree diagram that shows the subgroups formed in each step of the clustering of the UPP in the Traditional group, and the extent of their similarity. The secondary analysis describes three subgroups (clusters) of Traditional characteristics, which have been classified, for their socioeconomical and productive descriptors, as follows: High, Medium and Low, showing significant differences (p< 0.05) in some of the studied variables (Table 2).

Table 1. Analysis of the variables used for the general classification of the UPP in municipalities of the Huasteca Alta Veracruzana region.

UPP (N=135) Variables	Business (n= 4)	Transition (n= 29)	Traditional (n= 102)	P value
Age (in years)	52.51 ± 0.70	45.55 ± 0.31	45.55 ± 0.16	0.9096
Educational level (years)	17.00 ± 2.95	13.37 ± 0.96	8.81 ± 0.61	0.0001
Experience (years)	24.25 ± 5.89	28.89 ± 3.05	19.47 ± 1.68	0.0298
Surface (Ha)	250.50 ± 25.25	110.51 ± 9.41	20.58 ± 1.62	0.0001
Adult cows (n)	273.00 ± 63.5	83.01 ± 14.01	18.66 ± 3.10	0.0001
Weaned calves (n)	57.00 ± 32.45	42.55 ± 10.46	12.06 ± 3.49	0.0001
Cows / Hectare (n)	1.07 ± 0.18	0.78 ± 0.11	0.99 ± 0.06	0.2384
Technological index (0-1)	0.61 ± 0.06	0.58 ± 0.03	0.37 ± 0.01	0.0001
Reproductive index (0-1)	0.30 ± 0.10	0.35 ± 0.04	0.23 ± 0.01	0.0008
Health index (0-1)	1.00 ± 0.00	0.88 ± 0.03	0.69 ± 0.02	0.0001
Grazing index (0-1)	0.45 ± 0.15	0.52 ± 0.05	0.23 ± 0.01	0.0001
Nutritional index (0-1)	0.58 ± 0.20	0.42 ± 0.04	0.31 ± 0.02	0.0166
Administrative index (0-1)	0.68 ± 0.11	0.63 ± 0.08	0.27 ± 0.03	0.0001

p = probability of making a type-I error, analyzed with a one-way variance analysis, and compared with the Tukey method; p<0.05.

Table 2. Analysis of the variables used for the classification of the Traditional UPP in municipalities of the Huasteca Alta Veracruzana.

UPP (n=102) Variables	Low Traditional (n= 31)	Medium Traditiional (n= 37)	High Traditional (n= 34)	P value
Age (years)	57.77 ± 0.17	40.00 ± 0.27	45.44 ± 0.277	0.0001
Educational level (years)	4.13 ± 0.77	11.00 ± 0.97	10.71 ± 1.016	0.0001
Experience (years)	38.71 ± 1.92	9.16 ± 1.31	13.15 ± 2.447	0.0001
Surface (Ha)	13.71 ± 1.71	9.86 ± 0.83	38.53 ± 2.458	0.0001
Adult cows (n)	12.19 ± 1.44	10.46 ± 1.15	26.91 ± 1.692	0.0001
Weaned calves (n)	5.26 ± 0.89	5.05 ± 0.56	9.97 ± 0.866	0.0001
Cows / Hectare (n)	1.11 ± 0.13	1.08 ± 0.08	0.81 ± 0.093	0.0781
Technological index (0-1)	0.34 ± 0.01	0.33 ± 0.02	0.45 ± 0.023	0.0001
Reproductive index (0-1)	0.21 ± 0.01	0.22 ± 0.01	0.28 ± 0.022	0.0271
Health index (0-1)	0.70 ± 0.03	0.63 ± 0.03	0.77 ± 0.035	0.0161
Grazing index (0-1)	0.21 ± 0.03	0.23 ± 0.03	0.26 ± 0.029	0.4821
Nutritional index (0-1)	0.32 ± 0.03	0.23 ± 0.04	0.39 ± 0.033	0.0151
Administrative index (0-1)	0.11 ± 0.03	0.24 ± 0.06	0.46 ± 0.076	0.0011

p = probability of making a type-I error, analyzed with a one-way variance analysis, and compared with the Tukey method; $p<0.05$.

Based on these two clustering, it is reported that 5 types of UPP are present in the Huasteca Alta Veracruzana region (Figures 2 and 3); Business, Transition, High Traditional, Medium Traditional and Low Traditional, with significant differences in their socioeconomical and productive descriptors, and in their characteristics (Table 1 and 2). The Business UPP is characterized by a greater area (> 250 ha.), and, consequently, a higher number of cows and weaned calves; the educational level of the stockbreeder is 17 ± 2.95 years (College). Remarkable are the technological (0.60 ± 0.06) and health index (1.0 ± 0.00) of the farm, in which the practices are carried out in their entirety; and the administrative index (0.68 ± 0.11), because the accounting records are legible and up-to-date (Table 3). In the group of UPP classified as Transition it can be observed that the stockbreeders' educational level is 13.37 ± 0.96 (completed high school education), and that the size of the UPP exceeds 100 hectares (110 ± 9.4), with a considerable number of cows and weaned calves, greater than that of the Traditional group ($p < 0.05$). The technological index is similar to that of the Business group (0.58 ± 0.03); the best results are in the health index (0.88 ± 0.03), with most of the practices applied, and the administrative index (0.63 ± 0.82), with the accounting records detailed and updated. The pasture (grazing) index is greater in the Transition (0.52 ± 0.05) UPP than in the Business (0.45 ± 0.15) and Traditional ($p<0.05$) UPP, and the use of rotation grazing and enhanced pastures. The Transition group corresponds to those stockbreeders with the greatest experience in livestock husbandry ($p<0.05$).

The nutrition index is greater in the UPP classified as Business (0.58 ± 0.20) than in those classified as Transition (0.42 ± 0.04); these differences can be explained with the fact that the cattle of the Business UPP are more frequently fed with commercial products. Lastly, the reproductive indices are low in both categories: Business (0.30 ± 0.10) and Transition (0.35 ± 0.04), due to the fact that the implementation of reproductive technologies is low in both cases, and the use of bulls (natural mating) is more frequent as the main reproductive method.

In the UPP classified as Traditional, the land plots are smaller than 20 ha (20.68 ± 1.62); thus, the number of adult cows and weaned calves (26.91 ± 1.692 and 9.97 ± 0.866) is lower than in the Business and Transition UPP. The technological index is 0.37 ± 0.01, and the health index is 0.69 ± 0.02, with limited use of viral vaccines; the grazing index is low (0.23 ± 0.01), with extensive use of the natural grasslands for the feeding of the cattle. The other farming indices are low: few stockbreeders keep records (administrative index), and mineral and energy supplementation are not frequently practiced, even dry season (nutritional index).

The second clustering analysis describes the subgroups of the Traditional UPP. Results showed 3 different groups ($p<0.05$), High, Medium and Low Traditional, based on the socioeconomical characteristics of the stockbreeder and the UPP, as well as on the farming areas. Remarkable characteristics are a lower educational level (4.13±0.77, incomplete elementary education), and an older age (57.77±0.17) in the Low Traditional cluster. The High Traditional stands out for its greater technological index (0.45 ± 0.02) and health index (0.77±0.03), in comparison to the other two groups.

Description of the classified UPP. Based on the 5 classifications, determined according to the cluster succession, different variables, such as the characteristics of the stockbreeder, were analyzed, as described in table 3.

Table 4 describes the inherent characteristics of the UPP; and lastly, Table 5 describes the structure of the farm within the UPP.

A generalized opinion of the stockbreeders of all types of UPP of the Huasteca Alta Veracruzana region is that the lack of water supply and soil degradation are the main problems that they face (Table 4), because it hinders fodder production and water supply for the animals.

Table 3. Analysis of the stockbreeder variables, used for the classification of the UPP in municipalities of the Huasteca Alta Veracruzana.

Stockbreeder characteristics (N=135)		Business n= 4 (%)	Transition n= 29 (%)	High Traditional n= 34 (%)	Medium Traditional n= 37 (%)	Low Traditional n= 31 (%)
Gender	Female	1 (25)	3 (10.5)	6 (17.5)	8 (21.5)	2 (6.5)
	Male	3(75)	26 (89.5)	28 (82.5)	29 (78.5)	29 (93.5)
Age (in years)	Less than 20	0 (0)	0 (0)	0 (0)	2 (5.4)	0 (0)
	21-30	0 (0)	3 (10.5)	5 (14.7)	6 (16.2)	0 (0)
	31-40	1 (25)	3 (10.5)	7 (20.6)	7 (18.9)	0 (0)
	41-50	0 (0)	5 (17.0)	3 (8.8)	7 (18.9)	3 (9.5)
	51-60	1 (25)	8 (27.5)	10 (29.4)	8 (21.6)	9 (29)
	61-70	2 (50)	7 (24)	5 (14.7)	4 (10.8)	11 (35.5)
	Older than 71	0 (0)	3 (10.5)	4 (11.8)	3 (8.1)	8 (26)
Educational level	Elementary	0 (0)	2 (7)	11 (32)	12 (33)	11 (35.8)
	Junior high	0 (0)	3 (10.5)	4 (12)	3 (8)	5 (16)
	High school	0 (0)	5 (17)	2 (6)	3 (8)	0 (0)
	Undergraduate	4 (100)	18 (62)	16 (47)	16 (43)	1 (3.2)
	Uneducated	0 (0)	1 (3.5)	1 (3)	3 (8)	14 (45)
Experience	Ages (average ± ee)	24.25 ± 6.27	28.89 ± 2.33	13.14 ± 2.15	9.16 ± 2.06	38.7 ± 2.25

Table 4. Analysis of the characteristic variables of the UPP used for the classification in municipalities of the Huasteca Alta Veracruzana region.

Characteristics of the UPP (N=135)		Business n= 4 (%)	Transition n= 29 (%)	High traditional n= 34 (%)	Medium traditional n= 37 (%)	Low traditional n= 31 (%)
Property system	Private	4 (100)	26 (89.5)	29 (85)	21 (57)	8 (26)
	Communal	0 (0)	3 (10.5)	5 (15)	12 (32)	22 (71)
	Rental	0 (0)	0 (0)	0 (0)	4 (11)	1 (3)
Public utilities	Drinking water	1 (25)	5 (17)	4 (12)	4 (11)	6 (19.3)
	Electric power	4 (100)	15 (52)	16 (47)	12 (32.5)	8 (25.8)
Aspects of the land	Monoculture (Grass)	4 (100)	23 (80)	22 (65)	28 (75)	17 (55)
	Forage trees	4 (100)	22 (76)	29 (85)	30 (81)	27 (87)
	Ecological preserve	4 (100)	7 (24)	11 (32)	5 (13.5)	5 (16)
	Eroded soil	4 (100)	19 (65.5)	23 (67)	26 (70)	15 (48)
	Water deficit	4 (100)	21 (72.5)	18 (53)	23 (62)	22 (71)
Water sources	Dams	3 (75)	22 (76)	28 (82)	34 (92)	27 (87)
	Wells	0 (0)	7 (24)	2 (6)	3 (8)	3 (9.6)
	Streams	0 (0)	0 (0)	3 (9)	2 (5.4)	3 (9.6)
	Rivers	0 (0)	2 (7)	5 (14)	1 (2.7)	0 (0)
	Lagoons	1 (25)	0 (0)	0 (0)	0 (0)	1 (3.2)

Table 5. Analysis of the variables of farm structure of the UPP used for the classification in municipalities of the Huasteca Alta Veracruzana.

Farm structure in the UPP (N=135)		Business n= 4	Transition n= 29	High traditional n= 34	Medium traditional n= 37	Low traditional n= 31
Animals of the livestock farm (Heads)	Adult cows	273 ± 63.5	83.0 ± 14.0	33 ± 5.8	10.4 ± 1.15	13.3 ± 1.6
	≤ 12 months	57 ± 32.45	42.5 ± 10.4	17.5 ± 1.8	9 ± 1.5	9.7 ± 1.3
	12 - 24 months	26 ± 13.5	41.5 ± 12.1	9.25 ± 1.06	5.9 ± 0.7	5.8 ± 1.8
	≥ 24 months	40 ± 16.80	27.2 ± 5.5	10 ± 1.48	3.4 ± 0.51	2.6 ± 0.58
	Horses	5.5 ± 0.64	3.7 ± 0.4	2.4 ± 0.3	1.16 ± 0.26	1.5 ± 0.33
	Sheep	0.0	0.1 ± 0.07	0.1 ± 0.05	0.08 ± 0.04	0.16 ± 0.06
Characteristics of the farm	Females / stud	40 ± 5.7^{c}	20.5 ± 1.88^{a}	21.1 ± 2.04^{a}	12.0 ± 2.59^{b}	15.1 ± 3.09^{ab}
	Adult cows (%)	77.6 ± 8.7^{b}	52.3 ± 2.8^{a}	50.9 ± 3.09^{a}	46.0 ± 3.9^{a}	49.7 ± 4.6^{a}
	Milking cows (%)	0.0	58.0 ± 7.25^{a}	56.2 ± 5.9^{a}	62.6 ± 7.5^{a}	61.6 ± 7.2^{a}
	Replacements (%)	10.6 ± 4.2^{a}	14.9 ± 1.3^{a}	15.6 ± 1.5^{a}	15.2 ± 1.9^{a}	11.9 ± 2.2^{a}
	Weaning age (months)	8.0 ± 1.4^{a}	8.4 ± 0.47^{a}	8.0 ± 0.5^{a}	7.5 ± 0.65^{a}	7.0 ± 0.7^{a}
	Sale age (months)	8.0 ± 2.6^{a}	11.1 ± 0.8^{a}	9.1 ± 0.9^{a}	9.8 ± 1.1^{a}	9.2 ± 1.4^{a}
	Annual discarding (%)	7.5 ± 7.6^{a}	14.4 ± 2.4^{a}	12.8 ± 2.6^{a}	15.0 ± 3.4^{a}	9.9 ± 4.0^{a}
	Extraction (%)	58.2 ± 11.5^{b}	32.2 ± 3.7^{a}	29.8 ± 4.1^{a}	30.0 ± 5.1^{a}	25.6 ± 6.2^{a}

$^{a, b, c,}$ different letters between columns indicate significant differences (Tukey, $p < 0.05$).

DISCUSSION

The classification of the UPP found in the Huasteca Alta Veracruzana region differs from that found in the District Council for Sustainable Rural Development N° 151 from the state of Tabasco (8), where three types of stockbreeder were identified; however, there are similarities with the SPDP classifications reported by Rangel et al. (17), Cuevas et al (5), Juárez et al (3) in Mexico state, Sinaloa, and central Veracruz, who found more than 3 UPP groups. The Traditional type has subclassifications in the Huasteca Alta Veracruzana, as has been reported (3) in this cattle farming system in central Veracruz. However, Espinosa et al. (21) report only two types of UPP in five states (Veracruz, Nayarit, Campeche, Colima and Sinaloa); the first one, with a medium technological development level, and a second one with a low technological development level. These differences can be explained by the fact that the SPDP is established in agro-ecological regions with dry and humid tropical climates, and these conditions, among other variables, determine the characteristics of the production system.

The Business UPP have a higher extraction rate, in comparison with Transition and Traditional systems ($p<0.05$), and the same can be observed in Tabasco and Mexico state. Granados et al (8) and Rangel et al (17) found that the Business UPP clusters maintained a higher year-round volume of sales of milk and feeder calves; with this, these UPP keep a higher level of investment on technology, and the acquisition of external resources (feed, mineral salts, fodder) conserve the dynamism of the production system. In the Business UPP, the health and administrative indices stand out from the rest ($p<0.05$), which partially coincides with the findings in Mexican states (17) with the highest health index. The higher availability of financial resources determines the type and number of technological practices that can be implemented in a productive unit.

Juárez et al (3) found that the stockbreeder group that counts with the UPP with the largest area (104.66 ± 24.33 ha) in central Veracruz also have the highest level of technification. In this group, where the technological level is higher, there is also a higher educational level and lower age of the stockbreeders, unlike the rest of the groups in the SPDP, even in other regions of the country (3,5,17). Stockbreeders' age and educational level are factors that determine the extent of adoption of technological practices in developing countries (18,19,20).

The Transition group stands out for a greater use of technological practices for the better handling of fodder. In this respect, Cuevas and Rosales (20) report similar results in Northwestern Mexico, where the UPP that put

greater emphasis in milk production apply a larger number of technologies in the use and handling of fodder; however, this differs with the results of Espinosa et al (21), who found that, in the UPP with a medium technological level in several states of the country, the most developed indices are nutrition, administrative and health.

The reproduction technological index is one of the lowest in all of the UPP of the Huasteca Alta Veracruzana, and in the SPBP in other Mexican regions (22). It is simpler to use bulls for mating with cows, although this makes minimal the genetic improvement of the farm. It has been advanced that stockbreeder organizations and government institutions shall promote the use of technological practices in reproduction (controlled mating, artificial insemination, embryo transfer) to improve the cattle genetics (19) in the region.

Lastly, the limited production of fodder is not exclusive of the Huasteca Alta Veracruzana region; there is a similar situation in the SPBP of Northwestern Mexico (20). The climatological conditions of the region make the Temperature-Humidity Index reach values that surpass the comfort level of the animals at least 7 months per year (Figure 1), which causes low production and reproduction indices, originating low extraction rates in most of the UPP. To this, if is added the prolonged drought period (2018 – 2020) in the Huasteca Alta Veracruzana, which has compelled the stockbreeders to cut down their stock, as mentioned by Murray and Jaramillo (23) in the analysis of the impact of extreme climatological phenomena (drought) on the bovine, ovine and caprine livestock in Mexico.

In conclusion, the technological index of the SPDP on the Huasteca Alta Veracruzana lies between a medium and low level. The characterization and typification of this production system allowed the identification of the less developed zootechnics areas in each of the UPP groups, evidencing the technology transfer needs and the direction to follow for the design of policies for the development of the farming sector of the region. In the SPDP of the Huasteca Alta Veracruzana, the productive and reproductive parameters are low; this is due to the fragmentation of the production system, the lack of business vision, scarce technological development, and the current climatological conditions. It is necessary to evaluate the bovine genetic groups and fodder crops currently in use in the Huasteca Alta Veracruzana, in order to identify those that show greater resilience to the current conditions.

Conflict of interest

The authors of this study declare that there is no conflict of interest in its publication

Acknowledgements

The authors would like to acknowledge the help of the National Council for Science and Technology, and the Regional Stockbreeders' Union of Northern Veracruz.

REFERENCES

1. Palma JM. Escenarios de sistemas de produicción de carne de bovino en México. Av Investig Agropecu. 2014; 18(1):53-62. http://ww.ucol.mx/revaia/portal/pdf/2014/sept/sup_1/3.pdf

2. Román SI, Rios A, Montaño M, García A, Vega VE, Sifuentes AM, et al. Mejoramiento genético de los bovinos del trópico. En: Rodríguez O, Coordinador Editorial. Estado del arte sobre investigación e innovación tecnológica en ganadería bovina tropical. México: REDGATRO CONACyT; 2015. https://redgatro.fmvz.unam.mx/assets/rn9.pdf

3. Juárez-Barrientos JM, Herman-Lara E, Soto-Estrada A, Avalos-de la Cruz DA, Vilaboa-Arroniz J, Díaz-Rivera P. Tipificación de sistemas de doble propósito para producción de leche en el distrito de desarrollo rural 008, Veracruz, México. Revista Científica. 2015; 25(4):317-323. https://www.redalyc.org/articulo.oa?id=95941173007

4. Ku JC, Juárez FI, Mendoza GD, Romano JL, Shimada AS. Alimentación del ganado bovino en las regiones tropicales de México. En: Rodríguez O, Coordinador Editorial. Estado del arte sobre investigación e innovación tecnológica en ganadería bovina tropical. México: REDGATRO CONACyT; 2015. https://redgatro.fmvz.unam.mx/assets/rn9.pdf

5. Cuevas V, Loaiza A, Espinosa JA, Vélez A, Montoya MD. Tipología de las explotaciones ganaderas de bovinos doble propósito en Sinaloa, México. Rev Mex Cienc Pecu. 2016; 7(1):69-83. https://doi.org/10.22319/rmcp.v7i1.4150

6. Rojo-Rubio R, Vázquez-Armijo JF, Pérez-Hernández P, Mendoza-Martínez GD, Salem AZM, Albarran-Portillo B, et al. Dual purpose cattle production in Mexico. Trop Anim Health Prod. 2009; 41(5):715–721. https://doi.org/10.1007/s11250-008-9249-8

7. Gaceta Oficial del Estado de Veracruz. Programa Sectorial Alimentando a Veracruz 2019-2024 [Online]. México: Gobierno del Estado de Veracruz; 2019. http://www.veracruz.gob.mx/finanzas/wp-content/uploads/sites/2/2019/11/Alimentando-veracruz.pdf

8. Granados-Rivera LD, Quiroz-Valiente J, Maldonado-Jáquez JA, Granados-Zurita L, Díaz-Rivera P, Oliva-Hernández J. Caracterización y tipificación del sistema doble propósito en la ganadería bovina del Distrito de Desarrollo Rural 151, Tabasco, México. Acta Univ. 2018; 28(6):47–57. https://doi.org/10.15174/au.2018.1916

9. Canozzi ME, Rocha P, De Souza O, McManus CM, Dill MD, Jardim JO. Typology of beef production systems according to bioeconomic efficiency in the south of Brazil. Cienc Rural. 2019; 49(10):1–9. https://doi.org/10.1590/0103-8478cr20190030

10. Cortés JA, Cotes A, Cotes JM. Structural features of dual-purpose cattle production system in the Colombian humid tropic. Rev Colomb Cienc Pecu. 2012; 25(2):229–239. https://revistas.udea.edu.co/index.php/rccp/article/view/324750/20782154

11. Avilez JP, Meyer J, Nahed J, Ruiz FA, Mena Y, Castel JM. Classification, characterisation and strategies for improvement of cattle and sheep pasture systems in marginal areas of Southern Chile. Rev Mex Cienc Pecu. 2018; 9(2):240-262. https://doi.org/10.22319/rmcp.v9i2.4491

12. Rust JM. The impact of climate change on extensive and intensive livestock production systems. Anim Front. 2019; 9(1):20–25. https://doi.org/10.1093/af/vfy028

13. INEGI. Anuario estadístico y geográfico de Veracruz de Ignacio de la Llave 2017 [On line]. México: Instituto Nacional de Estadística Geografía e Informática; 2017. http://internet.contenidos.inegi.org.mx/contenidos/Productos/prod_serv/contenidos/espanol/bvinegi/productos/nueva_estruc/anuarios_2017/702825094980.pdf

14. Otzen T, Manterola C. Técnicas de muestreo sobre una población a estudio. Int J Morphol. 2017; 35(1):227-232. http://dx.doi.org/10.4067/S0717-95022017000100037

15. Orantes-Zebadua MA, Platas-Rosado D, Córdova-Avalos V, De los Santos- Lara MC, Córdova-Avalos A. Caracterización de la ganadería de doble propósito en una región de Chiapas, México. ERA. 2014; 1(1):49–58. https://era.ujat.mx/index.php/rera/article/view/6

16. De Freitas W, Pinheiro E. Nível tecnológico e seus determinantes na apicultura cearense. RPA. 2013; 22(3):32–47. https://seer.sede.embrapa.br/index.php/RPA/article/view/764/721

17. Rangel J, Perea J, De-Pablos-Heredero C, Espinoiza-Garíz JA, Toro MP, Feijoo M, et al. Structural and technological characterization of tropical smallholder farms of dual-purpose cattle in Mexico. Animals. 2020; 10(1):1–13. https://doi.org/10.3390/ani10010086

18. Mwangi M, Kariuki S. Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. JESD. 2015; 6(5):208-216. https://iiste.org/Journals/index.php/JEDS/article/view/20710/21632

19. Galina CS, Turnbull F, Noguez-Ortiz A. Factors Affecting Technology Adoption in Small Community Farmers in Relation to Reproductive Events in Tropical Cattle Raised under Dual Purpose Systems. Open J Vet Med. 2016; 6(1):15–21. https://doi.org/10.4236/ojvm.2016.61003

20. Cuevas-Reyes V, Rosales-Nieto C. Characterization of the dual-purpose bovine system in northwest Mexico: Producers, resources and problematic. Rev MVZ Cordoba. 2018; 23(1):6448–6460. https://doi.org/10.21897/rmvz.1240

21. Espinosa JA, Vélez A, Góngora SF, Cuevas V, Vázquez GR, Rivera JA. Evaluación del impacto en la productividad y la rentabilidad de la tecnología transferida al sistema de bovinos de doble propósito del trópico mexicano. Trop Subtrop Agroecosyst. 2018; 21(2):261–272. https://www.revista.ccba.uady.mx/ojs/index.php/TSA/article/view/2411/1147

22. Villarroel-Molina O, De-Pablos-Herederos C, Rangel J, Prosperina M, García A. Usefulness of Network Analysis to Characterize Technology Leaders in Small Dual-Purpose Cattle Farms in Mexico. Sustainability. 2021; 13(4):2291. https://doi.org/10.3390/su13042291

23. Murray-Tortarolo GN, Jaramillo VJ. The impact of extreme weather events on livestock populations: the case of the 2011 drought in Mexico. Clim Change. 2019; 153(1–2):79–89. https://doi.org/10.1007/s10584-019-02373-1